Fiat 595 Abarth Convertible Roof Manufacturing Report

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Group 1a

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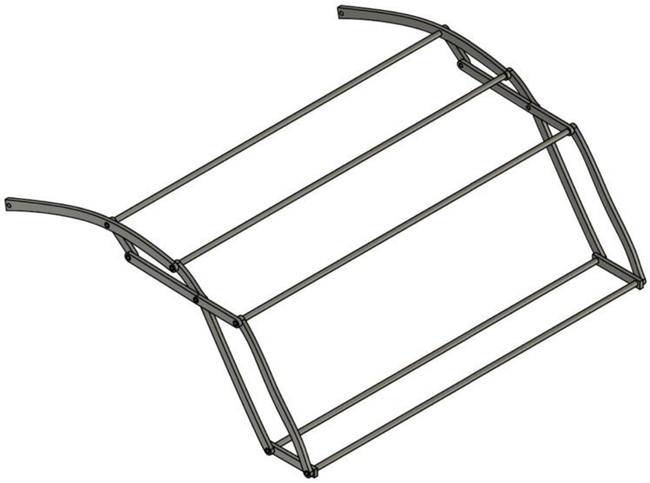
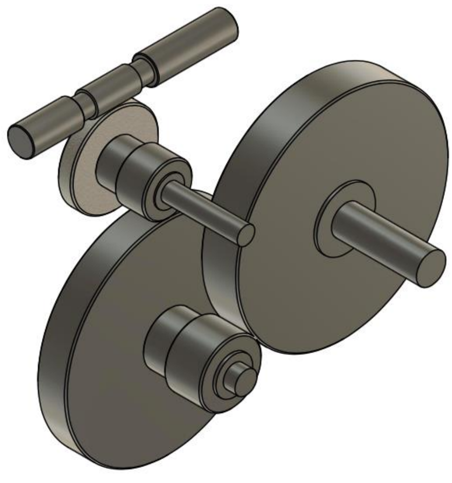
Abstract

The assignment was to design a convertible roof mechanism for the Fiat 595 Abarth with an aim to put it in direct competition with the BMW Mini Cooper convertible. This report aimed to test the feasibility of a proof of concept, with the goal of mass production. Through the several stages of the project, concepts were rigorously assessed prioritising cost and safety and maintaining level performance. Combining technical analysis with thorough mechanical design, it was decided that this system would be developed and taken forward to the engineering team at Abarth.





M1. Component Manufacturing

The component chosen as the focus for the manufacturing section is member 5. It retains the largest dimensions and the most complex geometry making it most expensive in-house component to manufacture.

M1.1. Workpiece

Before considering manufacturing operations for the component, a low alloy steel workpiece was selected. Choosing to source stock material rather than processes such as sand casting was decided as casting would require the material to be appropriately temperature treated. Doing this in-house would rely on greater overall energy expenditure and thus, an increase in manufacturing costs. Workpiece specification depends on the maximum thickness of the component with member 4 being 12mm. One option was a flat sheet, however, by industrial standard, the maximum thicknesses produced are limited to 6.35mm [1]. Steel plates were found to be the most suitable workpiece as they come in a larger range of thicknesses between 1.6mm and 250mm [2]. Engineering Toolbox states that steel plates are typically stocked at 2000mm x 3000mm, which is sufficient for the dimensions of member 4. Sourcing alloy steel from a supplier provides options for different types of treatments such as annealed or heat-treated which both allow for easier workability and in some cases an increase in strength. A 12.5mm 4140-alloy steel plate was then sourced from Metal Supermarkets seen in the Bill of Materials in D8.4. Table 9.

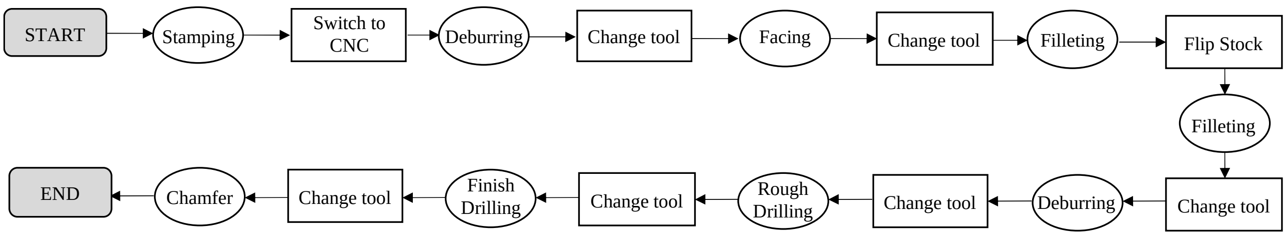
M1.2. Manufacturing Process

The first manufacturing process was machining the member geometry from the stock. A CNC machining process was initially considered to allow for good control over surface finish and the ability to hold very tight tolerances. The machining rate for milling, however, was slow and restricted by the metal removal rate which can be low on alloy steels. Running a CAM simulation on Fusion 360 showed that the milling process took 3 minutes. Alternatively, a more suitable process was metal stamping which has a much higher rate of production while still retaining respectable control over tolerances. Drawbacks of metal stamping include limitations to thin materials with a maximum thickness of 12.7mm [3], however, the stock material selected has a 12.5mm thickness which is just within the acceptable limits. Since the stock material is edging towards the upper limits of the process capabilities, bigger machines and more robust tooling would be required. A temperature treated stock is also necessary to allow for maximum ductility to prevent cracking. Finally, a bespoke mould would also need to be specially designed which can connote an increase in costs, however, the substantial reduction in machining time can be justified to tolerate the high volume of production.

The next set of processes implemented a CNC machine due to its sheer flexibility and variety of cutting tools which can be used at a low cost. High-speed steel (HSS) was selected to be the tooling material for all the milling processes besides deburring as its alloyed materials allow for continuous high-speed cutting in ferrous metals. After the stamping operation, there are likely to be small imperfections which need to be deburred. Mechanical deburring was applied to one side of the part using a 60mm deburring brush. Secondly, facing off the stock with a 50mm face mill to achieve the required material thickness. Due to the stock only being 0.5mm in excess, one pass was sufficient to achieve the desired thickness as the tool was set to a maximum cutting depth of 1mm. Then, all the fillets on the component were machined using a 2-step process, as the stock required to be flipped over to mill both sides. The face mill was replaced with a 2mm radius tool, set to a 2D contour. Multiple passes were initially considered to get a roughing and then a finishing pass for a smoother surface finish. This was dismissed as the finish of the fillets was insignificant and would require a change in tooling, increasing the processing time. Reducing process time was heavily prioritised as the cost for using a CNC is rated by the hour and reducing the manufacture time allows for more components to be produced for a lower cost. After flipping the stock, a repeat of the filleting operation was completed followed by the remaining deburring process. The radius tool was then replaced by an 11.8mm drill to drill out the 3 holes. To achieve both the H7 tolerance for the hole diameter and a high-quality surface finish, a 12mm reamer was then used to repeat the drilling operation. The final operation was to machine the chamfers located on the end of the holes. A 16mm 45° countersink was fitted to the CNC and set to a 2D contour.

The processes utilising a CNC machine were simulated on Fusion 360 to determine an appropriate estimate for overall machining time. The 9 processes were found to take an estimated time of 20 minutes and 48 seconds not including the time taken to change tools and flip over the stock material. A manufacturing process flow chart can be seen in Fig. 1.

Figure 1: Manufacturing process flow chart



M2. Costing

The overall manufacturing cost of the part can be broadly split into 3 categories: components, assembly, and overhead as seen in Fig. 2 [4]. For this scenario, the assembly cost can be dismissed as only one component was considered in the manufacturing section. The overhead costs can be assumed to be taken forward by a different department and was also not considered.

<u>M2.1. Component Analysis</u>

The first cost consideration was the cost of the stock material. CustomPartNet [5] provided a convenient stock costing estimator. The stock dimensions were inputted 650mm x 100mm x 12.5, with a run quantity of 15000 as the demand for the Abarth 595 in 2021 was 6500 [6]. A defect rate of 3% was used alongside a cut charge of 1.5$/part and a 10% markup to give an approximate price per sheet of 5.73$ (£4.58). The cost for running a CNC machine is on average about £45/hour [7]. With the obtained value of time taken during the CNC processing of 20 minutes and 48 seconds, a value of £15.6/part was calculated. Finally, the cost of tooling was considered, and the sourced corresponding tools and their prices can be seen in Table 1. The total cost for tooling was determined to be £853.88. This value may seem high but can be justified as each tool would be utilised for large quantities of production, therefore the cost per unit part would be significantly decreased. According to Maker Industry, router bits used for metal machining should be replaced annually [8]. Therefore, an estimated tooling cost per part was calculated as £0.057.

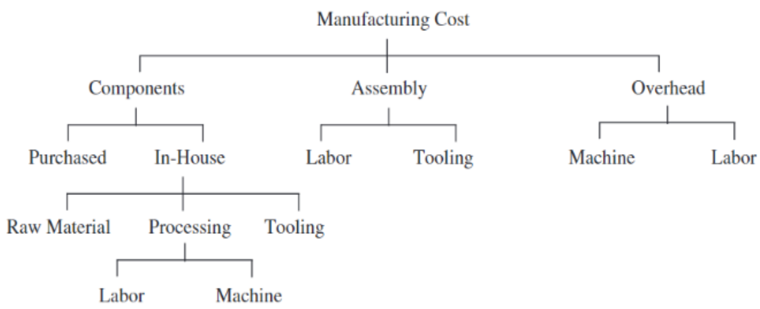


Figure 2: Efficiency for all motors

Table 1: Tooling cost spreadsheet

Tool	Part number	Unit Cost [£]	Source
60mm Xebec Brush Surface [9]	A21-CB60M	729.37	Xebec
FEIN HSS 50mm Cutting Diameter Magnetic Drilling Hole Cutter [10]	63134260052	37.83	RS Components
2MM HSS Sc/Sh Corner Rounding Cutter [11]	ZT1155493X	26.39	Zoro
Bosch HSS-G Twist Drill Bit, 11.8mm x 142 mm [12]	2608585536	12.12	RS Components
Dormer HSS 12mm x Morse Taper Shank Reamer Bit [13]	B101 12MM	32.64	RS Components
RS PRO Countersink x16mm1 Piece [14]	218-589	15.53	RS Components
	Total	**853.88**	

It can be assumed that running a stamping machine would be more expensive than that a CNC machine. This is because the machine is expected to exert multiple tons of force requiring a lot of energy and therefore, assumed that the rate was double running a CNC machine, £90/hour. Assuming the stamping process takes 5 seconds, the running cost would total £0.125/part**.** The cost for the bespoke die can range between £800 to £4000 [15] and member 5 can be assumed to be within the upper end of that range due to size and thickness. Therefore, taking the value as £3000**,** and assuming they need to be replaced annually, the cost per part comes out to £0.2. Therefore, it can be estimated that the overall cost for manufacturing member 5 is £21.712.

M.3. References

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